

What is claimed is:

1. A method for separating bitumen material from mineral particulates in grains of a hydrocarbonaceous ore, comprising the steps of:
  - a) mixing said ore with water to form an aqueous slurry of said grains;
  - b) tempering said slurry to a temperature between about 20°C and 150°C;
  - 10 c) shearing said slurry for at least one minute;
  - d) adding a peroxide to said slurry;
  - e) forming oxygen bubbles between said bitumen material and said mineral particulates within said grains by decomposing a portion of said peroxide therein; and
  - 15 f) separating said bitumen material from said mineral particulates.

2. A method in accordance with Claim 1 comprising the further steps of:
  - 20 a) attaching oxygen bubbles to said bitumen material;
  - b) buoying said separated bitumen material upwards in said slurry to form a bitumen-rich froth upon a primary water phase thereof; and
  - c) recovering said bitumen-rich froth from said primary
  - 25 water phase.

3. A method in accordance with Claim 2 comprising the further steps of:
  - a) settling said mineral particulates in said primary water
  - 30 phase; and
  - b) removing said settled mineral particulates from said primary water phase.

4. A method in accordance with Claim 3 comprising the further steps of:

- 5 a) adding water to said removed mineral particulates to form a second slurry;
- b) agitating said second slurry to separate entrained second bitumen material from said mineral particulates;
- c) attaching oxygen bubbles to said second bitumen material;
- 10 d) buoying said separated second bitumen material upwards in said slurry to form a bitumen-rich froth upon a second water phase thereof; and
- e) recovering said separated second bitumen material from said second water phase.

15 5. A method in accordance with Claim 4 comprising the further step of adding hydrogen peroxide to said second slurry.

6. A method in accordance with Claim 5 wherein said water is drawn at least in part from said primary water phase in  
20 said first separation tank.

7. A method in accordance with Claim 6 comprising the further steps of:

- 25 a) settling said mineral particulates in said secondary water phase; and
- b) removing said settled mineral particulates from said secondary water phase.

8. A method in accordance with Claim 2 comprising the  
30 further steps of:

- a) adding water to said bitumen-rich froth;
- b) adding hydrogen peroxide to said bitumen-rich froth to

cause additional separation of said froth into a bitumen layer, a water layer, and a mineral particulates layer.

9. A method in accordance with Claim 8 further  
5 comprising the step of supplying water from said water layer to said ore-mixing step.

10. A method in accordance with Claim 1 wherein said  
peroxide is selected from the group consisting of hydrogen  
10 peroxide and sodium peroxide.

11. A method in accordance with Claim 1 wherein said  
temperature is about 80°C.

15 12. A method in accordance with Claim 1 wherein said shearing is carried out at a shear rate generated by an average slurry velocity of at least one meter per second.

13. A method in accordance with Claim 12 wherein  
20 said shear rate is generated by an average slurry velocity of between two and five meters per second.

14. A method in accordance with Claim 1 wherein said  
shearing step is carried out for at least one minute before said  
25 step of adding peroxide.

15. A method in accordance with Claim 1 wherein said  
shearing step is carried out for between about 8 minutes and  
about 16 minutes before said step of adding peroxide.

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16. A method in accordance with Claim 1 wherein said  
shearing of said slurry is continued after said step of adding

peroxide.

17. A method in accordance with Claim 1 wherein at least a portion of said method is carried out at a gauge pressure  
5 of about 1 atmosphere.

18. A method in accordance with Claim 1 wherein at least a portion of said method is carried out at a gauge pressure of between about 1 atmosphere and about 5 atmospheres.  
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19. A method in accordance with Claim 18 further comprising the step of adding a cutter stock to said bitumen as a part of said recovering step.

20. A method in accordance with Claim 18 wherein said recovering step includes a method selected from the group consisting of gravity flotation, air flotation, settling, decanting, filtration, centrifugation, and combinations thereof.  
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21. A method in accordance with Claim 20 further comprising the step of recycling at least a portion of said water from said water phase into said mixing step to form said slurry.  
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22. A method in accordance with Claim 21 wherein said sand is employed as a filter for said water being recycled into said mixing step.  
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23. A method in accordance with Claim 1 wherein said peroxide is present in said slurry after said adding step in an amount between 0.05 weight percent and about 10.0 weight percent  
30 relative to the weight of water in said slurry, said percents being expressed as equivalent weights of hydrogen peroxide.

24. A method in accordance with Claim 1 further comprising the step of adjusting the weight ratio of water to ore to between about 1:4 and about 2:1 during said mixing step.

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25. A method in accordance with Claim 1 wherein said ore is selected from the group consisting of tar sands, oil sands, oil shales, and oil sandstones.

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26. A method in accordance with Claim 1 wherein said ore includes clay-size particles.

27. A method in accordance with Claim 1 wherein said mineral substrate includes quartz sand.

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28. A method in accordance with Claim 1 wherein said method is carried out in a process type selected from the group consisting of continuous, semi-continuous, batch, and combinations thereof.

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29. A method in accordance with Claim 1 further comprising the step of treating said ore prior to said mixing step.

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30. A method in accordance with Claim 29 wherein said treating is selected from the group consisting of sieving, sorting, crushing, grinding, and combinations thereof.

31. A method in accordance with Claim 29 wherein said treating is carried out with the assistance of a rotary trommel screen.

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32. A method in accordance with Claim 1 further comprising the step of collecting gaseous hydrocarbons generated in said method.

5           33. A method in accordance with Claim 1 wherein said water is selected from the group consisting of fresh water, sea water, salt water, tailing pond water, recycled process water, and combinations thereof.

10           34. A system for separating bitumen material from mineral particulates in grains of a hydrocarbonaceous ore comprising:

          a) means for mixing said ore with water to form an aqueous slurry of said grains;

15           b) means for tempering said slurry to a temperature between about 20°C and 100°C;

          c) means for shearing said slurry for at least one minute;

          d) means for adding a peroxide to said slurry;

20           e) means for forming oxygen bubbles between said bitumen material and said mineral particulates within said grains by decomposing a portion of said peroxide therein; and

          f) means for separating said bitumen material from said mineral particulates.

25           35. A system in accordance with Claim 34 further comprising:

          a) means for buoying said separated bitumen material upwards in said slurry to form a bitumen-rich froth upon a water phase thereof; and

30           c) means for recovering said separated bitumen material from said water phase.

36. A system in accordance with Claim 35 further comprising:

a) means for settling said mineral particulates in said water phase; and

5        b) means for removing said settled mineral particulates from said water phase.

37. A system in accordance with Claim 34 wherein said peroxide is selected from the group consisting of hydrogen  
10       peroxide and sodium peroxide.

38. A system in accordance with Claim 34 wherein said temperature is about 80°C.

15       39. A system in accordance with Claim 34 wherein said shearing means is capable of shearing said slurry at a shear rate produced by a slurry average velocity of at least one meter per second.

20       40. A system in accordance with Claim 39 wherein said shearing means is capable of shearing said slurry at a shear rate by a slurry average velocity of at least five meters per second.

25       41. A system in accordance with Claim 34 wherein said separating bitumen material from mineral particulates may be carried out at a gauge pressure of up to about 1 atmosphere.

30       42. A system in accordance with Claim 34 wherein at least a portion of said separating bitumen material from mineral particulates may be carried out at a gauge pressure of between about 1 atmosphere and about 5 atmospheres.

43. A system in accordance with Claim 35 further comprising means for adding a cutter stock to said bitumen.

5           44. A system in accordance with Claim 35 wherein said means for recovering step includes means selected from gravity flotation, air flotation, settling, decanting, filtration, centrifugation, and combinations thereof.

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<sup>45.</sup>

46. A system in accordance with Claim 36 further comprising means for recycling at least a portion of said water from said water phase into said mixing step to form said slurry.

<sup>46.</sup>

15           <sup>47.</sup> A system in accordance with Claim 34 further comprising means for treating said ore prior to said mixing step.

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<sup>46</sup>

48. A system in accordance with Claim <sup>46</sup>~~47~~ wherein said means for treating is selected from the group consisting of sieving, sorting, crushing, grinding, and combinations thereof.

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<sup>48.</sup>

<sup>46</sup>

49. A system in accordance with Claim <sup>46</sup>~~47~~ wherein said means for treating includes a rotary trommel screen.

<sup>49.</sup>

25           <sup>50.</sup> A system in accordance with Claim 34 further comprising means for collecting gaseous hydrocarbons.

<sup>50.</sup>

51. A system in accordance with Claim 34 wherein said shearing means includes a plurality of mixers.

<sup>51.</sup>

30           <sup>52.</sup> A system in accordance with Claim 34 wherein said shearing means and said peroxide-adding means includes a linear oxidation vessel capable of producing a low axial flow velocity



and a high tangential and rotational flow velocity in said slurry.

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§2.

5 ~~53~~. A system in accordance with Claim 36 wherein said means for settling and said means for removing includes a separating tank.

§3.

§2

~~54~~. A system in accordance with Claim ~~53~~ wherein said means for removing includes a drag chain conveyor.

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§4.

§2

~~55~~. A system in accordance with Claim ~~53~~ wherein said means for settling and said means for removing includes a sparger for injecting gas bubbles into said slurry.

§5.

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~~56~~. A system in accordance with Claim ~~53~~ wherein said separating tank includes an inverted weir.

§6.

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~~57~~. A system in accordance with Claim 34 further comprising means for heating said water prior to adding said water to said mixing means.

§7.

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~~58~~. A system in accordance with Claim 34 wherein said mixing means includes a first vessel, said shearing means includes a second vessel, and said separating means includes a third vessel.

§8.

§2

~~59~~. A system in accordance with Claim ~~58~~ wherein said first vessel is a mixing tank, said second vessel is a shearing device, and said third vessel is a separation tank.

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§9.

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~~60~~. A system in accordance with Claim ~~58~~ wherein at least said second and third vessels are configured for continuous

flow therethrough.

<sup>60.</sup>

<sup>61.</sup> A system in accordance with Claim 34, further comprising:

- 5 a) means for adding water to said removed mineral particulates to form a second slurry;
- b) means for agitating said second slurry to separate entrained second bitumen material from said mineral particulates;
- c) means for attaching oxygen bubbles to said second bitumen
- 10 material;
- d) means for buoying said separated second bitumen material upwards in said second slurry to form a bitumen-rich froth upon a second water phase thereof; and
- e) means for recovering said separated second bitumen
- 15 material from said second water phase.

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<sup>62.</sup> A system in accordance with Claim <sup>60</sup>~~61~~ further comprising means for adding hydrogen peroxide to said second slurry.

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<sup>62.</sup>

<sup>63.</sup> A system in accordance with Claim <sup>60</sup>~~61~~ further comprising:

- a) means for settling said mineral particulates in said secondary water phase; and
- 25 b) means for removing said settled mineral particulates from said secondary water phase.